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Nationaal Lucht- en Ruimtevaartlaboratorium
National Aerospace Laboratory NLR

AMS Tracker Thermal Control Subsystem

TTCB FM Vibration test procedure

Primary box

AMSTR-NLR-PR-030
ISSUE 3.0
MAY 14 2009

Sun Yat-Sen University (SYSU)
National Aerospace Laboratory (NLR)
Instituto Nazionale di Fisica Nucelare (INFN)

	NAME	ORGANISATION/RESPONSIBILITY	SIGNATURE	DATE
PREPARED	J. van Es/A. Alvino	NLR/INFN		14/05/09
CHECKED	J. van Es	NLR / AMS TTCS System Eng.		14/05/09
AGREED	A. Pauw	NLR / AMS Company PA		14/5/09
APPROVED	J. van Es	NLR / AMS TTCS PM		14/05/09
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Contents

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Document change log

Change Ref.	*Section(s)*	*Issue 1.0*
-	All	Initial issue
Change Ref.	*Section(s)*	*Issue 2.0*
	4.1	Modified location and name of the accelerometer
	5.0	Step 3-4-5 and 10-11-12 deleted: test is performed in Teri and not in Rome
	5.0	Modified test sequence for TTCBP & TTCBS
	7.1	Related steps to ENEA facility deleted
	7.2	Related steps to ENEA facility deleted
	7.3	Related steps to ENEA facility deleted
Change Ref.	*Section(s)*	*Issue 3.0*
	4.1	Modified location on pump and changed to a 3-axis type

1 Scope of the document and test objective

This document contains the vibration test procedure for the TTCB-P FM and the TTCB-S FM. The objective of the test is to demonstrate the TTCB's can withstand Minimum Workmanship Level Vibrations. Before and after the test functional checks are performed to compare the system health prior and after tests.

2 Hardware under test

The hardware subjected to the vibration test are the TTCB-P FM , TTCB-S FM. Both models are flight hardware. A TTCB consists of completely integrated unit with the following components: 1 pump electronics box connected by an electrical cable to 2 pumps, accumulator, HX, 2 x APS, 2 x DPS, several heaters, Pt1000's and Dallas DS18s20 temperature sensors, and integrated TTCB start-up radiators.
The items are shown in Figure 2-1 to Figure 2-3.

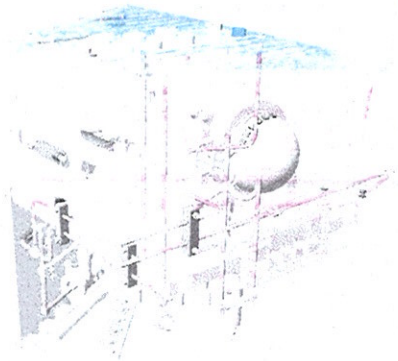


Figure 2-1: TTCB-Primary Box (3D-Model)

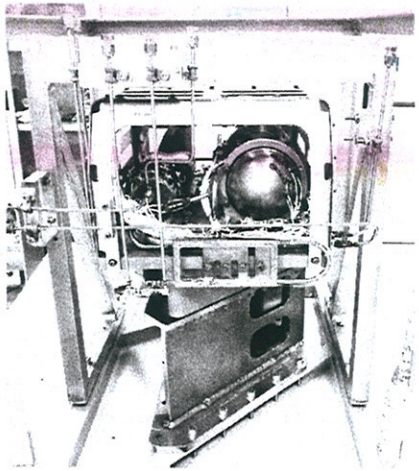


Figure 2-2: Picture of TTCB-Primary FM

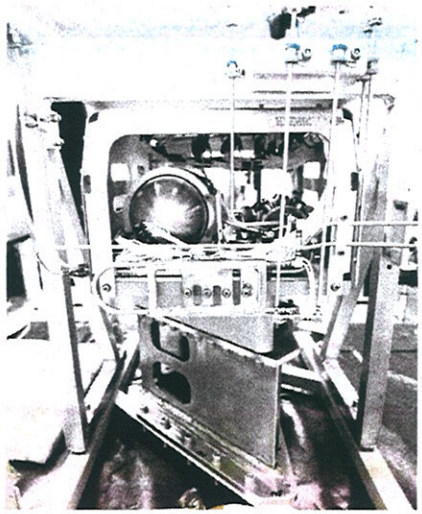


Figure 2-3: Picture of TTCB-Secondary FM

4.1 Location of accelerometers

The accelerometer to control the table will always be located on the interface plate with the vibration table. The position will be changed according to the test axis to be performed.

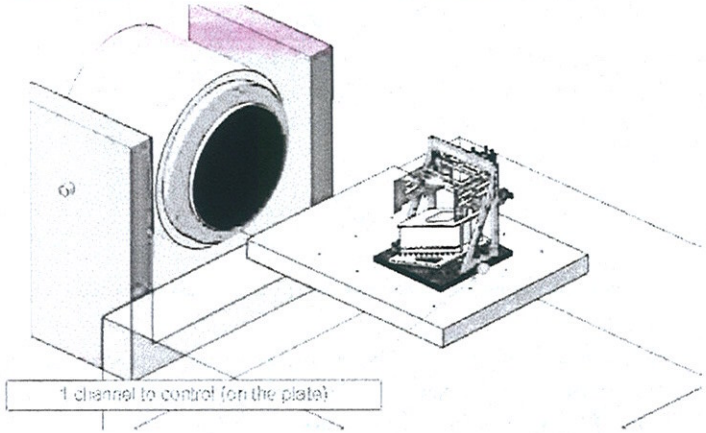


Figure 4-2: Location of the control sensor on the I/F plate (first axis)

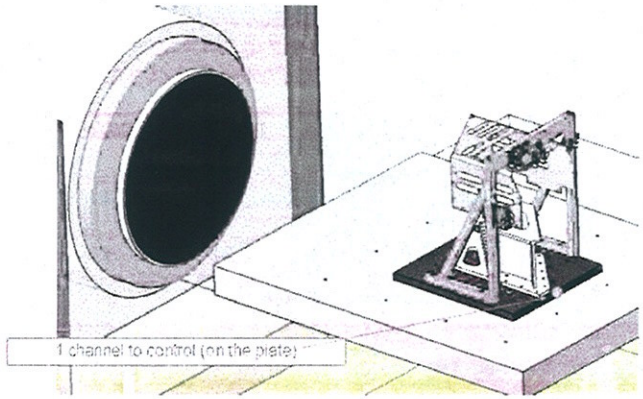


Figure 4-3: Location of the control sensor on the I/F plate (second axis)

3 Test Requirements and success criteria

The test is successful when the following requirements are fulfilled.

- No visual damage of the test article is found
- No significant discrepancies between pre- and post sine sweep curve response
- All mechanics frequencies are above 50Hz
- Functional check before and after show no discrepancies

4 Test facility description and measurement equipment

The test is performed at in Terni.
The following equipment will be used:

- Vibration test facility
- Digital camera for documentation of visual inspection
- Accelerometers to monitor and control the vibration
- Additional 3-axis accelerometer to monitor the pump vibrations

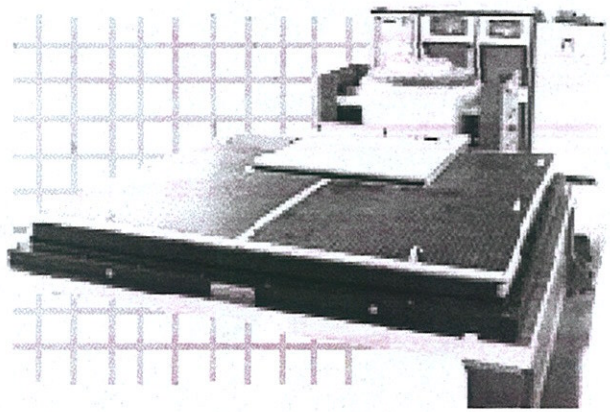


Figure 4-1: Vibration table @ SERMS

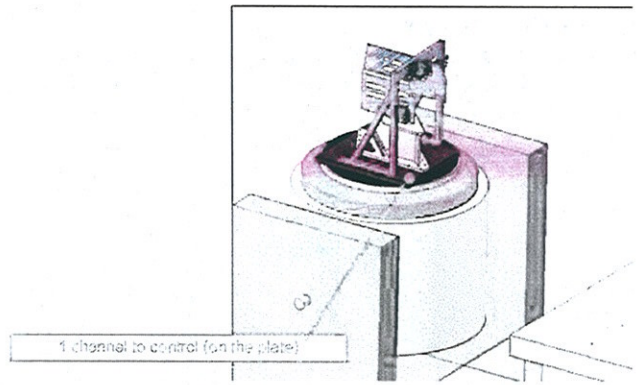


Figure 4-4: Location of the control sensor on the I/F plate (third axis)

Two other sensors will be applied to measure the response in the orthogonal directions. As the base plate is the most representative part the locations proposed are as close to the base plate as possible.

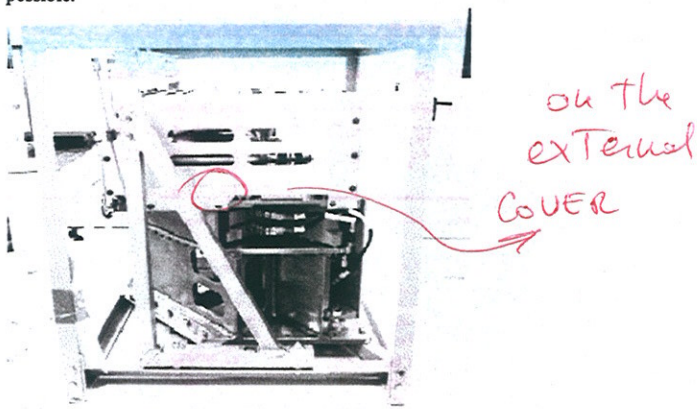


Figure 4-5: Location of the response accelerometers 1 on the TTCB

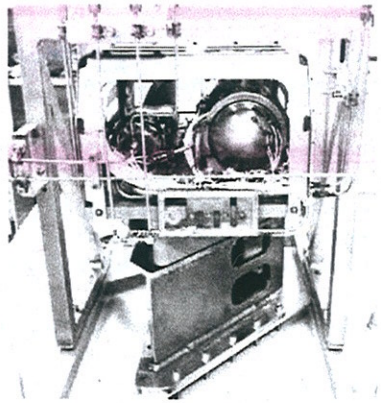


Figure 4-6: Locations of the response accelerometer 2 on the TTCB

Special accelerometer close to the pumps

An additional 3-axis sensor will be located on or close to the pumps so the vibration levels of the most critical component are monitored. This should be done to be sure the pumps are not overstressed.

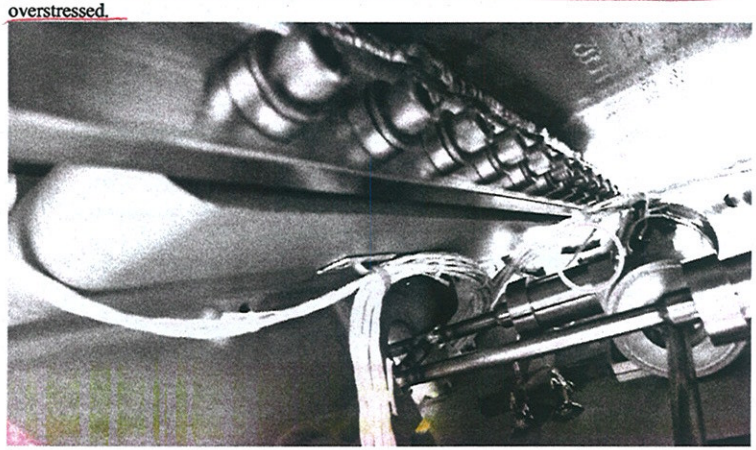


Figure 4-7: Location of the accelerometer close to the pumps (also used for 3rd axis response)

The steps for the SECONDARY box are exactly the same as for PRIMARY.

6 References documents

	Title	Number	Date
RD-1	TTCS Requirements Verification Matrix FM H/W	AMSTR-NLR-PL-02 Issue 1.0	April 2007

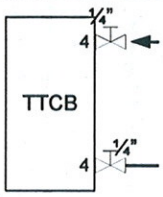
5 Test Procedure in main steps

The main test procedure steps for the PRIMARY box are:

1. Perform functional check TTCB at SERMS in Terni according to AMSTR-NLR-PR-028 "TTCB Limited functional check Vibration procedure"
2. Close valves and decouple test loop from the TTCB
3. Monitor the environment temperature during vibration testing
4. Perform first axis vibration test on TTCBP
    a. Install the TTCB on the vibration facility
    b. Perform a pre sine sweep to detect large workmanship failures and to characterize the system mechanics before vibration
        i. Stop test as soon as failures are detected
    c. Perform first axis random vibration test
    d. Perform post sine sweep to characterize the system mechanics after vibration
    e. Perform visual inspection
5. Perform second axis vibration test on TTCBP
    a. Install TTCB in second vibration axis
    b. Perform pre sine sweep to characterize the system mechanics after vibration
    c. Perform second axis random vibration test
    d. Perform post sine sweep to characterize the system mechanics after vibration
    e. Perform Visual inspection
6. Perform frist axis vibration for TTCB S
7. Perform second axis vibration fro TTCB S
8. Perform third axis vibration test for TTCB P
    a. Install TTCB in third vibration axis
    b. Perform pre sine sweep to characterize the system mechanics after vibration
    c. Perform third axis random vibration test
    d. Perform post sine sweep to characterize the system mechanics after vibration
    e. Perform visual inspection
9. Perform third axis vibration test fro TTCB S
10. Couple loop to TTCB and open valves
11. Perform functional check according to AMSTR-NLR-PR-028

Yellow are preparation pre-test sheets;
Red are vibration test sheets;
Green are post-test sheets

7.1 TTCB vibration pre-test procedure sheets

	TTCB Box pre-test vibration sheets		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	Result	Comment	√
1.	Record model type		P / S	P		✓
2.	Perform filling of the vibration test loop according to AMSTR-SYSU-PR-024 FM TTCB Filling and venting procedure			OK		✓
3.	Copy the measured volume of the TTCB (total volume- volume external loop parts)		(Litre)	1.241		
4.	Copy the filling rate here		(g/litre)	557 g/l		
5.	Define maximum allowed temperature during vibration test	+62	(°C)	350 g/l	Copy to Appendix B table	
6.	Perform functional test according to AMSTR-NLR-PR-028				See separate procedure	
7.	 Close the valves connecting the loop			OK		✓
8.	Monitor Test Environmental Temperature during testing		(°C)		Automatic or table app B.	✓

↑ ASWN

↳ max T for MDP 160 bar with 557 g/l from Mollier diagram

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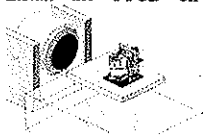
7 TTCB Vibration overall test procedure

The TTCB vibration test procedure sheets consist of 3 parts.

1. TTCB vibration pre-test vibration sheets
2. TTCB vibration vibration sheets
3. TTCB vibration post-test vibration sheets

	TTCB Box pre-test vibration sheets		company:		date: 19/5/2009	
	Fill in by hand.		engineer: RZ/AP		location:	
Step	Action	Monitoring	Value	Result	Comment	√
17.	Look inside box for -Loose particles due to shaving - Loose cables/harnesses - Loose bolts/nuts - Loose shaving protection of rivnuts			— — — —		✓
18.	Attachment of glued components	PT1000 heaters DS18s20		OK OK OK		✓
19.	Cable harness	Chafing/mounting		OK		✓
20.	Take pictures of TTCB from all sides					
21.	**End of sheet**					

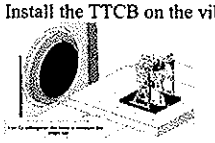
	TTCB Box pre-test vibration sheets		company:		date: 19/5/2009	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	Result	Comment	√
9.	**Install accelerometers**					
10.	Install the accelerometer to the Vibration I/F plate (figure 4.2)	Type/location		OK		✓
11.	Install the accelerometer 1 to the TTCB sides (see section 4.1)	Type/location		OK		✓
12.	Install the accelerometer 2 to the TTCB sides (see section 4.1)	Type/location		OK		✓
13.	Install accelerometer close to the pumps (see section 4.1)	Type/location		OK		✓
14.	Install the TTCB on the vibration table in first direction  Fasten flight bolts according to ATS of TTCB and fill forms Fasten non-flight bolts fill forms			OK		✓
15.	**Perform visual inspection prior to test**					
16.	**Visual inspection**, unaided eye, look at outer surface for - scratches - dents - cleanliness	 scratches Dents Particles/grease	 — ✓ some		 not in cleanroom	

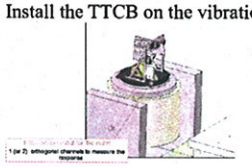
	TTCB Vibration test sheets X Y		company:		date: 19/5/2009	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	Result	Comment	√
10.	Check that the frequencies of the mechanics are well above 50Hz Document "response" curves			OK		√
11.	Document the last characterisation "response curve"		file name		report Antonio	
12.	**Perform visual inspection after test**					
13.	**Visual inspection**, unaided eye, look at outer surface for - scratches - dents - cleanliness	scratches Dents Particles/grease		- some particles	no deamon	
14.	Look inside box for -Loose particles due to shaving - Loose cables/harnesses - Loose bolts/nuts - Loose shaving protection of rivnuts			— √ — —		
15.	Attachment of glued components	PT1000 heaters DS18s20		— — —		
16.	Cable harness	Chafing/mounting		—		
17.	Take pictures of TTCB from all sides					

7.2 TTCB vibration test sheets

	TTCB Vibration test sheets		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	Result	Comment	√
1.	Record model type		P / S	P		
2.	**Scanning test to check loose parts and characterise**					
3.	Perform one PRE sine sweep from 5 to 1000 Hz 0,2 G – scan rate 1 oct/min	Check loose parts			If any loose parts are detected stop test	√
4.	If loose parts are detected improve attachments					
5.	Check that the frequencies of the mechanics are well above 50Hz Document "response" curves					√
6.	Repeat step 2-5 until no loose parts detected					√
7.	Document the last characterisation "response curve"		Write down file name		report Antonio	
8.	**Perform Random Vibration test first axis according to spectrum in Appendix A.**					√
9.	**Perform one POST sine sweep from 5 to 1000 Hz** **0,2 G – scan rate 1 oct/min**					

	TTCB Vibration test sheets		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	Result	Comment	√
25.	Look inside box for -Loose particles due to shaving - Loose cables/harnesses - Loose bolts/nuts - Loose shaving protection of rivnuts					√
26.	Attachment of glued components	PT1000 heaters DS18s20				√
27.	Cable harness	Chafing/mounting				
28.	Take pictures of TTCB from all sides					X
29.	**Perform one PRE sine sweep from 5 to 1000 Hz 0,2 G – scan rate 1 oct/min**	**Check loose parts**			**If any loose parts are detected stop test**	
30.	Check that the frequencies of the mechanics are well above 50Hz Document "response" curves					
31.	Document the last characterisation "response curve"		file name			
32.	**Perform Random Vibration test second axis according to spectrum in Appendix A.**					√

	TTCB Vibration test sheets		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	Result	Comment	√
18.	**End of first axis vibration**					
19.	**Second axis Vibration test**					
20.	Install the TTCB on the vibration table in second direction  Rotate 90° the plate (without unscrewing the bolt between box and fixture) to perform the second axis Fasten non-flight bolts					√
21.	**Install accelerometers**				by Antonio	
22.	Install the accelerometer to the Vibration I/F plate (figure 4.3)	Type/location			Indicate location/orientation change	
23.	**Perform visual inspection prior to test**					
24.	**Visual inspection**, unaided eye, look at outer surface for - scratches - dents - cleanliness	 scratches Dents Particles/grease		 — — particle		√

	TTCB Vibration test sheets		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
		heaters DS18s20				
40.	Cable harness	Chafing/mounting				
41.	Take pictures of TTCB from all sides					
42.	**End of second axis vibration**					
43.	**Third Axis Vibration test** — 20/5-05-20.					
44.	Install the TTCB on the vibration table in third axis direction  Rotate 90° the plate (without unscrewing the bolt between box and fixture) to perform the second axis Fasten non-flight bolts					✓

	TTCB Vibration test sheets		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
33.	**Perform one POST sine sweep from 5 to 1000 Hz** **0,2 G – scan rate 1 oct/min**					✓
34.	Check that the frequencies of the mechanics are well above 50Hz Document "response" curves					✓
35.	Document the last characterisation "response curve"		file name		by Antonio.	
36.	**Perform visual inspection after test**					
37.	**Visual inspection**, unaided eye, look at outer surface for - scratches - dents - cleanliness	 scratches Dents Particles/grease				
38.	Look inside box for -Loose particles due to shaving - Loose cables/harnesses - Loose bolts/nuts - Loose shaving protection of rivnuts					
39.	Attachment of glued components	PT1000				

	TTCB Vibration test sheets		company:		date: 2009-05-20	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
52.	Take pictures of TTCB from all sides					✓
53.	**Perform one PRE sine sweep from 5 to 1000 Hz 0,2 G – scan rate 1 oct/min**	**Check loose parts**			**If any loose parts are detected stop test**	✓
54.	Check that the frequencies of the mechanics are well above 50Hz Document "response" curves					
55.	Document the last characterisation "response curve"		file name		by Antonio	
56.	**Perform Random Vibration test third axis according to spectrum in Appendix A.**					✓
57.	Perform one POST sine sweep from 5 to 1000 Hz 0,2 G – scan rate 1 oct/min					✓
58.	Check that the frequencies of the mechanics are well above 50Hz Document "response" curves					✓
59.	Document the last characterisation "response curve"		file name		by Antonio.	1
60.	**Perform visual inspection after test**					
61.	**Visual inspection**, unaided eye, look at outer surface for - scratches	scratches				

	TTCB Vibration test sheets		company:		date: 2009-05-20	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
45.	**Install accelerometers (if needed)**					
46.	Install the accelerometer to the Vibration I/F plate (figure 4.4)	Type/location			Indicate location/orientation change	
47.	**Perform visual inspection prior to test**					
48.	**Visual inspection**, unaided eye, look at outer surface for - scratches - dents - cleanliness	scratches Dents Particles/grease				✓
49.	Look inside box for -Loose particles due to shaving - Loose cables/harnesses - Loose bolts/nuts - Loose shaving protection of rivnuts					✓
50.	Attachment of glued components	PT1000 heaters DS18s20				✓
51.	Cable harness	Chafing/mounting				✓

7.3 TTCB vibration post-test procedure sheets

	TTCB Box post-test vibration sheets		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
1.	Record model type		P / S			
2.	Check temperature monitoring during testing has been performed according to appendix B.				see appendix.	
3.	Perform functional test according to AMSTR-NLR-PR-028				See separate procedure	
4.	Perform venting of the vibration test loop according to AMSTR-SYSU-PR-024 FM TTCB Filling and venting procedure					
5.	**End of sheet**					

	TTCB Vibration test sheets		company:		date:	
	Fill in by hand.		engineer:		location:	
Step	Action	Monitoring	Value	**Result**	Comment	√
	- dents - cleanliness	Dents Particles/grease		— particle	— no cleanroom	✓
62.	Look inside box for -Loose particles due to shaving - Loose cables/harnesses - Loose bolts/nuts - Loose shaving protection of rivnuts			— — — —		✓
63.	Attachment of glued components	PT1000 heaters DS18s20		— — —		✓
64.	Cable harness	Chafing/mounting		/		✓
65.	Take pictures of TTCB from all sides					✓
66.	**End of third axis vibration**					

* 2 wires RMP-rad heaters cut during mounting z-axis vibration
* accelerometers have glued on Alu-tape. Alu tape directly on TTCB (NO kapton tape used)

Appendix A: Vibration profiles and levels

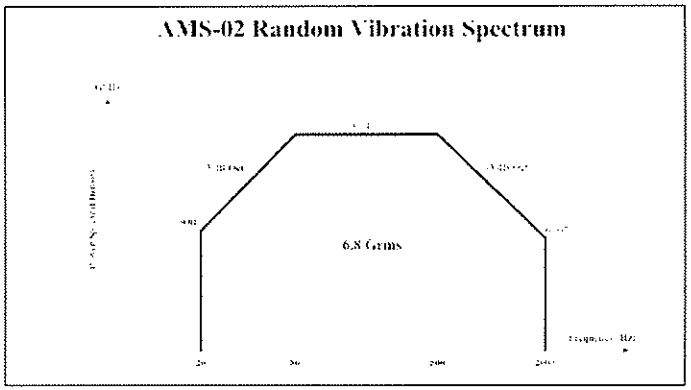
The TTCB's are subjected to Minimum Workmanship Level Vibration testing.
The requirements are as follows.

Table 15-2: Minimum Workmanship Levels for the Alpha Magnetic Spectrometer - 02

All Axes	20 Hz	0.01 g²/Hz
	20-80 Hz	+3 dB Octave
	80-500 Hz	0.04 g²/Hz
	500-2000 Hz	-3 dB Octave
	2000 Hz	0.01 g²/Hz
	Overall - 6.8 Grms	

Note: MWL Test duration: 60 seconds per axis

The profile is shown in the below figure.



AMS02 TTCB random vibration spectrum

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Appendix B: Temperature fill table during vibration test

(Will be used as reference to show to NASA P_{TTCB}< MDP (160 bar)
Max allowed temperature

Temperature monitoring during Vibration testing	
Write down max allowed Temperature (based on filling):.....[°C] Fill every 15 minutes (In case the maximum allowed temperature is almost reached fill every 5 minutes)	
TTCB Model (Primary/Secondary)	
Time	**Temperature [C]**

Before and after each axis random vibration test a sine sweep is performed to characterise to characterize the TTCB response curves. The Sine sweep definition is as follows.

Sine sweep from 5 to 1000 Hz – 0,2G – scan rate 1 oct/min

Temperature monitoring during Vibration testing **Write down max allowed Temperature (based on filling):.....[°C]** Fill every 15 minutes (In case the maximum allowed temperature is almost reached fill every 5 minutes)	
TTCB Model (Primary/Secondary)	
Time	**Temperature [C]**

Appendix C: I/F plate mechanical lay-out instructions

Error! Objects cannot be created from editing field codes.

Error! Objects cannot be created from editing field codes.

Error! Objects cannot be created from editing field codes.

Error! Objects cannot be created from editing field codes.

END OF DOCUMENT

AMSTR-NLR-PR-030 ISSUE Temperature log. Primary box

20/01/2009

TTCB-p z-axis vibration

from clean room T = 22°C

time	T_{cool} °C	T_{cover}	
10^{30}	24.5	25.5	
10^{37}	24.5	24.8	airco
10:42	24.0	23.1	
10:55	23.9	23.1	
11:00	23.8	22.9	
11:09	23.9	23.2	
11^{21}	24.8	25.2	vibration
11^{35}	25.9	26.5	on
11^{40}	25.4	25.4	amp. off
11:54	24.6	23.6	
12^{15}	24.8		table vibration

AMSTR-MLR-PR-0301
ISS 3.0.
Temperature log.

Primary box during vibration
Max $T_{allowed}$ = 62 °C ⇔ MOP = 160 bar
$T_{max,during\ test}$ = 27.4 °C ⇔ $P_{sat} \approx 74$ bar
TTCD-p filled with CO_2 on slip-tank cover out of cold climate chamber

time	T_{acc} (°C)	T_{cover} (°C)	
11 25	25.0	26.6	
11 40	25.5	26.9	
12 00	25.9	27.2	
12 20	26.6	27.9	
12 30	27.0	28.2	
12 46	27.3	28.3	
13 11	27.2	26.8	portable air-co
13 18	26.9	26.0	
13 31	26.5	25.7	
14 35	26.0	25.6	
14 57	26.6	26.6	
15 10	27.2	27.2	
15 15	27.4	27.6	
15 30	27.4	27.5	
15 35	27.3	26.8	
15 45	to climate chamber		

Conclusion:
P_{syst} << 160 bar.

2.9
4.3
3.0 2.1
2.54 1.07 1.06 2.94
0.54 0.74

Remark: T is logged in climate chamber
$T < T_{max,during\ test}$.